Spacecraft Avionics Miniaturization Using Embedded Passive Packaging Technology

Miniaturization of electronic packages will play a key role in future space avionics systems. Smaller avionics packages will reduce payloads while providing greater functionality for information processing and mission instrumentation. Current surface mount technology discrete passive devices not only take up significant space but also add weight. To that end, the use of embedded passive devices, such as capacitors, inductors and resistors will be instrumental in allowing electronics to be made smaller and lighter. Embedded passives fabricated on silicon or like substrates using thin film technology, promise great savings in circuit volume, as well as potentially improving electrical performance by decreasing parasitics. These devices exhibit a low physical profile and allow the circuit footprint to be reduced by stacking passive elements within a substrate. Thin film technologies used to deposit embedded passive devices are improving and costs associated with the process are decreasing.

There are still many challenges with regard to this approach that must be overcome. In order to become a viable approach these devices need to work in conjunction with other active devices such as bumped die (flip chip) that share the same substrate area. This dictates that the embedded passive devices are resistant to the subsequent assembly processes associated with die attach (temperature, pressure). Bare die will need to be mounted directly on top of one or more layers of embedded passive devices. Currently there is not an abundant amount of information available on the reliability of these devices when subjected to the high temperatures of die attach or environmental thermal cycling for space conditions. Device performance must be consistent over time and temperature with minimal parasitic loss.

Pretested and assembled silicon substrates with layers of embedded capacitors made with two different dielectric materials, Ta_2O_5 (TaO) and benzocyclobutene (BCB), were subjected to the die attach process and tested for performance in an ambient environment. These assemblies were subjected to environmental thermal cycling from -55° C to 125° C. Other substrates were assembled and tested with both embedded passive and surface mount active devices. Preliminary results indicate embedded passive capacitors and resistors can fulfill the performance and reliability requirements of space flight on future missions. Testing results are encouraging for continued development of integrating embedded passive devices to replace conventional electronic packaging methods.